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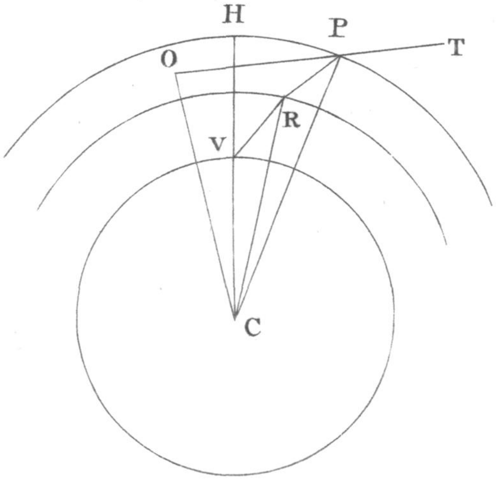
Refraction



An Account of Observations made at the Observatory of TRINITY COLLEGE, DUBLIN, *with an Astronomical Circle, eight feet in diameter, which appear to point out an annual parallax in certain fixed stars.*

Also a Catalogue of North Polar distances of forty-seven principal fixed stars, from recent observations, and a comparison thereof with those of the same stars, obtained by other instruments, and by the same instrument, at a former period. By JOHN BRINKLEY, D. D. M. R. I. A. F. R. S. *and* ANDREWS' *Professor of Astronomy, in the University of Dublin.*

Read May 9, 1814.

TO prove the motion of the earth about the sun, by actual observation of change of distance from some of the fixed stars, at different times of the year; has long been an object of research. Soon after the Copernican System became generally adopted, and while Astronomy was yet in an imperfect state, this was considered in some measure necessary to establish the truth of that system. Afterwards the discoveries in physical astronomy made this enquiry, as far as the above motive was concerned, less interesting.

Modern astronomers have looked to this object principally with a view of ascertaining whether any apparent annual motion of the fixed stars, from this cause, existed necessary to be noticed, in computing the mean place from the observed.

Dr. Bradley, by his celebrated observations, which led him to the discovery of the aberration of light, first established that as to certain stars no parallax existed capable of being noticed. His observations were made with an instrument, that, for observations near the zenith, has not since been surpassed.

Since his time it seems to have been generally allowed, that the annual parallax of every fixed star was too small to be noticed, till lately M. Piazzi, of Palermo, conceived that his observations pointed out a parallax in certain stars. An account of his conclusions is given in the Conn. des Temps, 1808, together with an account of some observations made at Rome on α Lyræ.

My observations, by the eight feet circle, which commenced in 1808, have pointed out also a parallax in α Lyræ, but considerably less than that observed by M. Piazzi. It is only with respect to this star and Arcturus that our conclusions agree in pointing out a parallax.* My observations tend to point out a parallax in α Lyræ, α Aquilæ, Arcturus, α Cygni, and α Ophiuchi, and some others. M. Piazzi considers α Aquilæ as having no discernible parallax, whereas my observations tend to point out that α Aquilæ has a greater parallax than any other star that I have observed. Besides this discordance between the results of my observations and those of M. Piazzi, it is to be noticed that other results obtained by instruments executed by the first artist, and by observers justly celebrated, do not accord with mine in pointing out a parallax. It is therefore with great diffidence that I offer my results to the Academy. These results tend to prove that the parallax (the angle subtended at the star by the *diameter* of the earth's orbit) of α Lyræ, by 152 observations amounts to 2″; of α Aquilæ, by 96 observations = 5″, 5; of Arcturus, by 92 observations = 2″, 2; of α Cyg-

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* I can only refer to the account of M. Piazzi's observations given in the Con. des Temps. 1808, p. 432. In which it is mentioned that the observations themselves are to be found in the 10th vol. of the Italian Society. By the account in the Con. des Temps, it appears that M. Piazzi observed in Procyon, a parallax of declination, such

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as would result from a double parallax of 20″ whereas by my observations I find no indication of parallax in *this* star. Indeed from the account given in the Con. des Temps, by M. Delambre, the results of M. Piazzi, as to parallax, cannot be considered as entitled to much confidence, and in consequence M. Delambre may appear justified in making the following remark.

" Malgrê les efforts dont nous venons rendre compte, il ne parait pas que nous " ayons encore rien de bien certain sur la distance des étoiles. Cette connaisance est " peut être du nombre de celles qui nous seront toujours refusées."

No one should consider this as reflecting any censure on the observations of a person who has rendered such excellent services to astronomy. It should only be understood that the instrument used by M. Piazzi was inadequate to the research.

ni, by 47 observations = 2″, 1.[*] The results as to other stars I shall reserve till my observations have been more numerous.

I shall endeavour to make such remarks respecting these results, that the Academy may form a proper judgment how far they serve to establish the important conclusion, which I conceive may be derived from them.

For this purpose it is necessary to give some account of the instrument by which the observations have been made.

The superiority of circles over quadrants, and the advantages derived from the micrometer microscope, are so well known, as to make it quite unnecessary, that they should be stated here.

About the year 1788, soon after the late celebrated artist Mr. Ramsden had strenuously recommended those improvements, which his mechanical skill had rendered so very practicable, the Provost and Senior Fellows of Trinity College, Dublin, by the advice of my predecessor, Dr. Usher, directed a circle, ten feet in diameter, to be made for this observatory. Mr. Ramsden protracted for many years the execution of the instrument. After beginning one of 10 feet diameter, he afterwards rejected it for one of 9 feet, which was actually divided. The latter he also rejected, and at his death he left unfinished our present instrument of 8 feet diameter. This was finished by his successor, Mr. Berge, and placed in the observatory, about the middle of 1808. The long period which elapsed, while the instrument was expected, will be always a subject of regret to myself. On some future occasion I may, perhaps, lay a detailed account of this instrument before the Academy. At present I shall only mention such particulars, as may be necessary to render intelligible the method of making observations with it, and the degree of accuracy to be expected from it.

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[*] Perhaps it may be objected to me that what I call parallax, should be called double parallax, since properly the parallax is the difference between the observed and mean place. In this way the

parallax of α Lyræ = 1″,0
of α Aquilæ = 2,7
of Arcturus = 1,1
of α Cygni = 1,0

But I believe that, generally, when the parallax of a fixed star is spoken of, the greatest change of place is intended, which is equal to the angle subtended by the diameter of the earth's orbit at a fixed star.

The circle is supported in a frame, which frame turns on a vertical axis. The upper part of the frame is of cast iron, turns in a collar, and is connected with the lower part of the frame by four hollow brass cylindrical pillars. The lower part of the frame, which is also of cast iron, terminates in a pivot of steel, which turns in a socket of bell-metal. This socket is moveable south and north, by one screw, and east and west, by another, for the purpose of adjusting the vertical axis.

The axis of the circle, a double cone four feet in length, is supported on Ys which are themselves supported by strong bars of brass attached to the cylindrical pillars. The pressure of the weight of the circle and its axis is relieved by an ingenious application of friction wheels and the lever. There is also an ingenious contrivance for adjusting the axis horizontal.

The circle of brass is divided into intervals of 5 minutes, which intervals are subdivided by micrometer microscopes into seconds and parts of a second as usual.

There are three microscopes. One called the bottom microscope, opposite the lowest part of the circle: a second opposite the left extremity of the horizontal diameter, and a third opposite the right extremity of the horizontal diameter.

The frame carrying the circle turns on the vertical axis with the greatest steadiness. The circle also turns on the horizontal axis with equal steadiness.

The vertical axis of the instrument is adjusted by a plumb line. The plumb line which performs this adjustment is about 10 feet long, and is suspended from a point about 8 inches from the centre of the top of the frame, and passes over a point below, 8 feet from the point of suspension. By help of this point which is moveable by a screw, and by the moveable socket below, the axis of the instrument is made vertical. The adjustment of this axis, as to the north and south positions is, it is evident, of the most essential consequence to the exactness of the zenith distance of the object observed. It is likewise evident that, from the great interval between the upper and lower parts of the instrument, the temperatures above and below must occasionally differ, and thence the relative positions of the point of suspension, and of the point below, be changed. To obviate this inconvenience, which would be fatal to the accuracy of the observations, the point of suspension is on a compound bar formed of bars of brass and steel, and the point below is also placed on a similar compound bar. By this the distance of the plumb line from the vertical axis remains always the same. This contrivance appears to answer in a very satisfactory manner.*

The axis of the instrument being adjusted vertical, and the plane of the circle in the meridian, and facing the east; let b, l, r, be the zenith distances of a star as shewn by the bottom, left and right hand microscopes respectively. When the plane of the circle is in the meridian, and facing the west, let b', l', r', be the zenith distances of the same star as shewn by the respective microscopes. Then the true zenith distance $= \frac{b+l+r+b'+l'+r'}{6}$ or $\frac{1}{2}\left(\frac{b+l+r}{3}+\frac{b'+l'+r'}{3}\right)$. And the correction of the mean of the three microscopes $=\frac{1}{2}\left(\frac{b+l+r}{3}-\frac{b'+l'+r'}{3}\right)$.

The accuracy of the result of an observation is affected

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* The circular instrument in plate 8 of Professor Vince's Practical Astronomy, may be referred to for our circular instrument. Except that in our instrument there is no azimuth circle. The plumb line is suspended in the position represented, but the compound bars are not represented. Also the pillar F is perforated for the insertion of the bottom microscope. The horizontal microscopes are not represented, and there is no microscope at *n*.

1. By the error of the mean of the six readings arising from inaccuracy in the divisions and error of eccentricity.

2. By inexact adjustment of the vertical axis.

3. By error of reading off,

4. By error of bisection of the star.

5. By error from change of temperature affecting the parts of the instrument.

From my examination of this instrument, I have reason to conclude there is no sensible error of eccentricity, and that as far as the divisions are concerned, the mean of the six readings can never occasion a greater error than 1″, and an error of this amount will take place only in very few parts of the circle. A comparison of the results determined by the bottom, and by the two horizontal microscopes: also a comparison of the corrections of the mean of the microscopes determined by stars at different distances from the zenith, seem to leave no doubt on this point.

It may appear an imperfection in this instrument that we cannot avail ourselves of a microscope at the highest part of the circle. The reading off a microscope so placed would be highly inconvenient, and on account of the circumstances of the instrument, the use of it might be attended with some danger, both to the observer and instrument. However it does not appear that the accuracy of the results would be materially affected by such an addition.

By means of the plumb line the vertical axis can in general be adjusted with great precision; but this operation is oftentimes very troublesome, and, it is to be feared, sometimes cannot be performed with the desired accuracy. The plumb line passing near the plane of the circle*, no screen can be used. Hence even a slight agitation of the air occasions a slow motion in the plumb line; and the observer, without much tedious precaution, may be deceived as to this essential adjustment. From hence, doubtless, have arisen greater discordances in the observations than would have otherwise taken place. This imperfection arises principally from the situation of the plumb line, it would not be difficult to give it another situation in which it might be safely screened from the agitation of the air, and were the instrument within a convenient distance from the maker, I should endeavour to have this alteration effected.

Notwithstanding this imperfection, I think I may safely pronounce that as far as errors of observation are concerned a mean of 10 observations (five the face of the circle being east, and five the face being west) will give the zenith distance exact to much less than one second, and that a mean of 20 observations, according to a very high degree of probability cannot induce an error of nearly half a second as far as errors of observation are concerned.

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* An adjustment of the microscopes was intended by means of the plumb line, and four gold dots placed on the limb of the circle. This made it necessary that the plumb line should pass very near the plane of the circle. But the method of observing thence resulting I found inferior both in accuracy and convenience to that in which the plumb line is only used for the adjustment of the vertical axis.

In errors of observation I include errors of adjustment in the vertical axis, errors of bisection of the star, errors of reading off, and also errors arising from changes of temperature in the instrument.

From what has been said, the principal circumstances relative to the astronomical circle at our observatory will be readily comprehended.

The angle to be obtained by each observation is the exact zenith distance of the object, from which, the zenith distance of the pole having been previously determined, the polar distance or declination of the object is known. The zenith distance can only be had by the assistance of a plumb line or spirit level. The inaccuracies and inconveniencies to which both these instruments are liable have long been known, and as the zenith distance is not necessary for finding the polar distance, it has been, sometime ago, proposed to find the polar distance without a reference to the zenith point, by simply observing the arches of the meridian intercepted between the object, the polar distance of which is required, and stars, the polar distances of which are known, or can be obtained by help of circumpolar stars.

Mr. Troughton, whose fame as an artist is justly so celebrated, has made several circles with this view, and has lately made a mural circle of 6 feet in diameter for the Royal Observatory at Greenwich. The recent construction of this instrument, in which Mr. Troughton has availed himself of his long experience and the latest improvements; the circumstance of the telescope admitting of being shifted to different parts of the circle; the number of microscopes used, and the firmness of their position in the pier; and the great knowledge, skill and assiduity of Mr. Pond, the Astronomer Royal, all promise very important results for Astronomy.

There is, however, one circumstance to be noticed, respecting this method of observing, of some importance, and which bears particularly on the question, whether any of the fixed stars have a visible parallax.

In the mode of ascertaining the north polar distance of an object by the mural circle, it is requisite to know the north polar distances of certain fixed stars with the changes from precession, effects of the semi annual equation, aberration, nutation and refraction. If some of these stars be also affected by annual parallax, it is obvious that if no notice be taken of this, the north polar distance required will be inexact. It may be said that the same correction being obtained by different stars, will shew that no such annual parallax exists so as to be sensible. This point certainly might be ascertained in this manner by a sufficiently numerous set of observations. Still, as it may be suggested, that many of the fixed stars may have small sensible annual parallaxes, observations, which will point out only the differences of these, are not so proper as those by which the whole quantity would be pointed out. This may perhaps be better understoood by considering what would have taken place had this mode of observing been used before the discovery of the aberration of light. It would have been extremely difficult to have separated the compound results, and assigned the proper quantity to each star, as Bradley was enabled to do at once, as to his observations by his zenith sector.

The observations I am about to state point out changes of zenith distance in certain stars at different seasons of the year, which changes are explained by annual parallax, and after long and anxious consideration I have not been able to assign any other cause.

α Lyræ near Opposition.

Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral. +
1808, July 28	W	14° 46′ 19″,93	,77
Aug. 21	E	20,41	,55
23	E	21,58	,53
24	W	18,03	,52
1809, June 17	E	21,49	,87
July 5	W′	17,38	,87
8	W	19,93	,86
13	E	21,03	,85
14	E	18,31	,84
15	E	17,86	,84
18	E	18,46	,83
19	W	18,74	,83
20	E	17,43	,82
23	E	19,18	,80
24	W	19,29	,80
25	W	21,79	,79
Aug. 4	W	19,76	,71
8	W	19,15	,67
9	E	20,73	,67
1810, July 1	E	19,67	,88
8	E	19,69	,86
9	W	19,22	,86
15	E	18,26	,84
24	W	18,27	,80
26	E	21,25	,78
27	E	17,32	,77
30	W	19,59	,75
1811, July 2	W	19,20	,88
7	W	18,96	,87
9	E	19,43	,87
10	W	19,49	,87
14	E	20,20	,85
16	W	18,13	,84
1811, July 17	E	14° 46′ 20″,80	,84
20	W	19,05	,82
21	E	21,28	,82
22	W	18,22	,81
23	E	17,56	,80
26	W	17,41	,78
29	E	18,02	,76
31	E	19,44	,75
Aug. 1	W	19,48	,74
3	E	20,94	,72
4	W	18,40	,71
5	E	21,81	,70
6	W	18,04	,69
1812, June 28	W	18,79	,88
July 3	E	18,10	,88
Aug. 6	E	18,42	,69
7	W	18,07	,68
8	W	18,44	,67
11	E	16,25	,65
24	E	20,28	,52
25	W	19,69	,51
27	E	19,59	,48
1813, July 2	E	20,42	,88
3	W	21,11	,88
4	E	21,30	,88
7	W	20,57	,87
8	E	19,44	,87
10	E	20,22	,86
14		19,63	,85
15	W	18,81	,85
20	E	16,21	,82
23	W	18,68	,80

α Lyræ near Conjunction.

Time of observation	Face of Circle	Mean Zen. Dist. Jan. 1. 1811.	Mult. for Paral.	Time of observation	Face of Circle.	Mean Zen. Dist. Jan. 1, 1811	Mult. for Paral.
		° ′ ″	—			° ′ ″	—
1808, Oct. 22	W	14 46 20,61	,33	1811, Dec. 10	W	14 46 21,53	,83
Nov. 2	E	22,59	,48	11	E	20,43	,83
6	E	22,57	,53	13	W	17,66	,85
Dec. 4	EW	18,99	,80	28	E	22,14	,88
5	EW	21,74	,81	29	W	22,62	,85
19	EW	20,91	,85	1812, Jan. 14	W	20,32	,83
22	EW	20,33	,88	19	E	21,25	,81
1809, Jan. 22	E	22,19	,80	20	E	21,48	,80
30	W	22,65	,73	21	W	20,68	,80
Dec. 7	E	19,53	,82	29	E	22,95	,72
1810, Jan. 22	E	22,20	,79	Dec. 2	W	20,85	,79
23	W	20,04	,78	8	E	21,58	,82
Feb. 4	E	21,30	,68	10	W	22,19	,83
9	W	20,81	,63	11	E	21,19	,84
13	E	18,49	,59	14	W	20,46	,85
18	E	18,53	,52	15	E	19,74	,85
1811, Jan. 10	E	20,14	,84	22	E	21,70	,88
11	W	18,71	,86	31	W	20,07	,88
12	E	21,65	,85	1813, Jan. 4	E	21,04	,87
15	W	22 89	,83	6	W	19,97	,86
16	W	21,62	,83	Nov. 28	E	19,48	,76
17	E	19,70	,82	Dec. 6	W	21,64	,81
20	W	19,71	,80	9	W	22,90	,83
21	E	21,73	,80	14	E	20,11	,85
22	W	22,55	,79	20	W	21,63	,87
23	E	22,86	,79	21	W	20,20	,87
Nov. 19	W	20,76	,68	26	W	19,85	,87
Dec. 2	W	20,79	,79	28	E	21,55	,88
5	E	23,24	,81	29	W	21,36	,88
				30	E	20,17	,88
				1814, Jan. 3	W	22,40	,88
				4	W	22,34	,88

α Lyræ near 6 o'clock in the Evening.

Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1. 1811.	Mult. for Paral.	Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1. 1811.	Mult. for Paral.
1810, Aug. 28	E	14 46 19″,17	+,46	1811, Oct. 11	E	14 46 20″,38	—,17
Sept. 5	W	17,79	+,35	12	W	18,91	—,17
7	E	20,00	+,32	16	E	20,03	—,24
8	E	19,98	+,31	1813, Sep. 29	W	18,09	—,00
16	W	21,21	+,20	Oct. 1	E	19,85	—,03
Oct. 1	E	20,61	—,03	3	W	20,21	—,07
2	E	20,56	—,06	6	E	21,03	—,11
5	W	18,84	—,10	7	W	19,67	—,13
6	W	21,53	—,11	8	E	22,95	—,14
7	E	20,64	—,13	11	W	17,48	—,17
8	E	20,16	—,14	14	E	20,35	—,22
15	E	22,82	—,23	15	E	20,85	—,23
1811, Oct. 9	W	22,78	—,14	18	W	20,88	—,27

The first column points out the day of observation. The second shews the position of the face of the circle. The third the mean zenith distance, Jan. 1, 1811, to which the observations have been reduced as being a middle epoch between the observations. The last column is the multiplier of the semiannual parallax to obtain the parallax in zenith distance at each observation. The product is to be applied, according to the sign, to the zenith distance in the third column, to obtain the mean zenith distance.

Let *p*. represent the semi annual parallax of α Lyræ.

	Mean	Zen.	Dist.
	°	′	″
Then by the first 20 observations near opposition	14	46	$19,51+,76p$
by next 20 - - - -			$19,07+,82p$
by next 25 - - - -			$19,26+,75p$
Mean of 65 observations near opposition	14	46	$19,28+,78p$
By first 20 observations near conjunction -	14	46	$20,84-,72p$
by next 20 - - - -			$21,24-,81p$
by next 21 - - - -		-	$21,01-,85p$
Mean of 61 observations near conjunction	14	46	$21,03-,79p$

Hence $19'',28p.+,78p = 21'',03-,79p.$
or $p = 1'',1$
and the parallax of the annual orbit for α Lyræ = $2'',2$.

Thus the mean zenith distance of α Lyræ, Jan. 1, 1811, by 126 observations = $14^{\circ}\ 46'\ 20'',15$

By the 26 observations, near 6 o'clock in the evening, the mean zenith distance, Jan. 1, 1811 = $14\ 46'\ 20'',25-,05p$.

If the above conclusion respecting the parallax of α Lyræ be not admitted, some explanation of the differences of the zenith distances must be sought for.

First, it cannot arise from errors of observation, comprehending error of adjustment in the vertical axis, error of bisection of the star, and errors of reading off. These errors by their nature are corrected by taking a mean of repeated observations, and an inspection of the result of each observation will shew that it is impossible a mean of 60 observations can be affected by a greater error of observation than a very small fraction of a second.

It occurred that the mean of the observations made and read off in day-light might differ from the mean of the observations made near midnight. It soon however was satisfactorily ascertained that the differences could not arise from this cause.

Secondly, the difference cannot arise from errors of division, for in fact the same divisions are used as to the same star. The correction of the mean of the microscopes, obtained by observations of different stars, which have been used to deduce the observed zenith distance of α Lyræ, although affected by errors of division, occasions no error in the result, because care has been taken that the numbers of observations East and West should be nearly equal. The zenith distances corrected for the mean of the microscopes have been put down merely to shew the consistency of the observations. The means of the zenith distances at each time of the year, depend only on the observations of α Lyræ itself.

Thirdly, it cannot arise from uncertainty in the changes of refraction. This star is too near the zenith for any material uncertainty of this kind.*

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* These observations have been calculated by Bradley's refractions. Had they been calculated by the French Tables, (which I have used for α Aquilæ and Arcturus) the parallax would have been about two seconds. This alteration arises from the differ-

Fourthly, it cannot arise from any uncertainty in the maximum of aberration of light; whether we take the maximum at $20''$ or $20\frac{1}{4}''$ Because when α Lyræ passes the meridian near noon and midnight, the aberration is very small, and therefore not affected by a small error in the maximum.

But it is necessary to compute with precision according to the sun's longitude at the time of the passage, as the aberration changes rapidly at these times. The semi annual equation is nearly the same at these times, and therefore no error from thence. The precession or any small uncertainty in the quantity of proper motion can occasion no error.

When indeed α Lyræ passes near 6 o'clock, then an uncertainty in the maximum of aberration may affect the conclusion, because the aberration in declination is nearly a maximum, and therefore in this enquiry it is of some consequence to know the maximum of aberration.

Hence the observations of α Lyræ near quadrature are less proper for this enquiry, and have accordingly been less attended to. Those that have been made are however very consistent with the observations made near noon and midnight.

The only solution, perhaps that we have left, unless we admit of parallax, is, that in different degrees of tempera-

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ent laws of change of density from change of temperature in Bradley's, and in the French Tables.—In α Lyræ it is scarcely worth notice, but is considerable in α Aquilæ. In that star the parallax comes out less by the French, than by Bradley's Refractions.

ture, the figure of the instrument changes, and gives different results for the same star. This cannot be the case.

For 1st. with respect to several stars, the results are the same when the means of the thermometer differ by many degrees. Thus,

α Polaris.

14	observations	mean therm.	55°,2	give	seconds in zen. dist.	-	5″,79
23	do.	mean therm.	39	give	do.	-	6,27
11	do.	mean therm.	41½	give	do.	-	6,02

α Polaris S. P.

23	observations	mean therm.	59°,8	give	seconds in zen. dist.	-	25″,26
21	do.	mean therm.	39,2		do.	-	25,65

The above are even computed by Bradley's formula for refraction which certainly gives the change of refraction from change of temperature too great.

Arcturus.

18	observations	mean therm.	59°	give	seconds in zen. dist.	-	34″,68
20	do.	do.	64		do.	-	34,92
23	do.	do.	40		do.	-	35,23

These are also computed by Bradley's refractions.

Secondly, if the figure of the instrument changed in different degrees of temperature, the zenith distance of a star, determined by the bottom microscope only would not preserve, in different temperatures, the same relation to the zenith distance determined by the mean of the three microscopes. No alteration however is observed to take place. Thus for α Lyræ the following are the corrections to be applied to the zenith distance by the *three microscopes* to give the zenith distance by the *bottom microscope* only.

			Correction.
Summer	-	1811	—0″40
Winter	-	1811	—0,26
Summer	-	1812	—0,46
Winter	-	1812	—0,07
Summer	-	1813	—0,03
Autumn	-	1813	—0,24

This indicates no change of figure, and the same is observed with respect to other stars. In α Aquilæ, for instance, the quantity to be applied to the mean of the three microscopes to give the result by the bottom microscope only = + 1″ nearly, and no material change occurs in different temperatures. *

Besides if this parallax arise from some deception, it ought to appear in *all* stars sufficiently near the zenith, so as not to be affected by uncertainty in change of refraction.

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* The difference between the mean of the three microscopes and the bottom microscope is no where greater than for α Aquilæ.

Capella, β Tauri Procyon, Polaris, above and below the pole, γ Draconis, β, ζ, η, Ursæ majoris and other stars do not shew changes of zenith distance similar to what appear as to α Lyræ, Arcturus, α Aquilæ, α Cygni, and α Ophiuchi.

The mean zenith distances from a number of observations of the pole star above and below the pole are given, as instances where no changes of zenith distance are noticed.* Also the results as to α Aquilæ, Arcturus and α Cygni. The results as to other stars which seem to have a sensible parallax will be given when the observations are more numerous.

If parallax be not admitted, it must appear very remarkable that in no stars have annual changes of zenith distance been observed by this instrument that cannot be explained by a parallax. It might be expected that in some stars the changes would have been quite opposite to the changes from parallax.

It may perhaps be suggested that there may be some unknown peculiarity in my mode of observing, that would explain these appearances of parallax. In answer to this it is only necessary to mention that many of the observations have been made by my son, Mr. John Brinkley, A. B. and comparing the results of our observations no differences are observed.

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* In the observations of the pole star, each zenith distance is the result of observations made before and after the meridian passage of the star, the instrument having been reversed in the interval. This has sometimes been done for other stars, but not often. The value of this instrument may be considered as much enhanced from being capable of being used at a small distance on each side of the meridian, by noting the time of observation.

α Polaris in the Spring.

Time of Observation.	Face of Circle.	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.
1809, Mar. 3	EW	34° 54′ 44″,51	+ ,86
Apr. 10	EW	46,84	,98
22	EW	44,70	,97
23	EW	46,45	,93
May 9	EW	46,33	,80
10	EW	43,77	,80
14	EW	43,77	,74
22	EW	45,09	,65
23	EW	45,67	,64
27	EW	44,50	,62
1810, Mar. 5	EW	44,27	,88
1810, Apr. 24	EW	34° 54′ 46″,35	+ ,91
26	EW	44,27	,91
May 27	EW	45.65	,56
29	EW	44,98	,54
30	EW	44,15	,53
1811, Mar. 27	EW	45,90	,99
Apr. 22	EW	46,11	,93
1814, Feb. 2	EW	45,63	,50
7	W	47,17	,58
9	W	44,54	,61
16	EW	45,05	,69
24	E	44,80	,79

The mean of 23 gives mean zenith distance $= 34° 54' 45'', 24. + ,76p$. The greatest zenith distance of the pole star when above the pole as affected by parallax, is on Oct. 4. and the least on April 2. Here as well as in the results which follow, the refraction has been computed by the French tables.

α Polaris in the Autumn.

Time of Observation.	Face of Circle.	Mean Zen. Dist. Jan. 1, 1811·	Mult. for Paral·	Time of Observation.	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.
1809, Oct 5	EW	34 54 43,22	,99	1811, Oct. 16	E	34 54 44,27	,97
7	EW	45,01	,99	22	W	45,42	,94
22	EW	44,50	,94	23	W	45,38	,94
26	EW	46,75	,91	27	W	46,42	,91
29	EW	47,04	,91	Nov. 5	E	45,47	,85
Nov. 1	EW	43,70	,88	19	W	46,07	,71
6	EW	42,71	,84	20	E	45,49	,69
14	EW	43,67	,77	29	W	47,43	,56
17	EW	47,06	.73	1812, Oct. 20	W	45,32	,95
18	EW	45,57	,72	24	E	46,88	,94
19	EW	45,09	,71	25	W	46,37	,93
21	EW	46,45	,69	26	E	45,76	,92
29	EW	44,95	,58	27	E	45,19	,92
Dec. 3	EW	46,70	,51	28	W	44,55	,91
7	EW	46,97	,44	Nov. 3	E	47,65	,87
10	EW	44,57	,39	5	E	46,84	,85
12	EW	47,44	,36	6	W	45,54	,84
1810, Nov. 6	EW	44,58	,84	7	E	44,93	,83
26	EW	43,85	,60	8	W	44,61	,82
Dec. 1	EW	45,64	,53				

Mean of 39 observations gives mean zenith distance = $34^\circ\ 54'\ 45'', 51-79p$. Comparing the two last sets of observations, viz. 23 in spring and 39 in autumn, we have $45'',24+,76p. = 45'',51-,79p$ or $p = 0',17$.

From which may be inferred that α Polaris has no sensible parallax.

α Polaris S. P. in the Spring.

Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.	Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.
			—				—
1809, Apr. 14	EW	38 18 48,55	,96	1810, Ap. 19	EW	38 18 47,54	,94
20	EW	49,89	,94	26	EW	47,83	,90
23	EW	49,81	93	27	EW	48,36	,89
May 9	EW	44,81	,80	28	EW	46,45	,88
10	EW	46,48	,78	30	EW	45,61	,87
14	EW	46,96	,74	May 2	EW	45,34	,86
18	EW	47,58	,70	5	EW	48,76	,83
22	EW	45,44	,67	1813, May 5	W	48,09	,83
23	EW	47,08	,66	9	E	46,67	,79
24	EW	45,68	,65	16	W	49,20	,72
June 4	EW	46,38	,47	19	E	48,03	,68
15	EW	46,16	,30	20	W	47,29	,67
17	EW	45,77	,26	21	E	47,92	,66
25	EW	45,74	,15	26	W	48,71	,59
			+	28	E	47,00	,56
July 10	EW	46,21	,09	29	W	48,58	,55
				June 1	E	46,89	,52

Mean of 32 gives mean zenith distance $= 38^\circ 18'' 47'', 21 - ,68p$.

α Polaris S. P. in the Autumn.

Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.	Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.
		° ′ ″	+				+
1809, Aug. 25	EW	38 18 46,97	,78	1811, Nov. 3	E	38 18 45,48	,87
Sep. 30	EW	48,11	,99	5	W	47,58	,85
Oct. 5	EW	44,78	,99	6	W	47,50	,85
24	EW	46,20	,93	11	E	47,70	,80
28	EW	48,98	,91	18	W	49,49	,72
31	EW	47,95	,88	22	E	46,27	,66
Nov. 16	EW	45,25	,74	1812, Oct. 14	W	45,77	,98
17	EW	46,51	,73	15	E	47,45	,98
18	EW	45,42	,72	20	W	46,57	,95
19	EW	47,14	,71	21	E	46,90	,95
21	EW	45,79	,69	23	W	48,10	,94
23	EW	46,90	,66	25	W	47,30	,93
Dec. 1	FW	46,75	,53	27	E	46,07	,91
11	EW	46,98	,37	28	W	45,75	,91
1810, Nov. 16	EW	47,35	,72	29	E	47,87	,90
1811, Oc. 15	W	46,31	,98	Nov. 2	E	45,46	,87
16	E	46,07	,98	3	W	46,66	,87
19	W	47,81	,96	4	E	47,05	,86
24	W	46,25	,93	5	W	45,65	,86
25	E	45,35	,93	6	E	45,83	.85
Nov. 1	W	46,99	,88	7	W	47,68	,84

The mean of 42 observations gives mean zenith distance = 38°.18′.46″,76+,84p. A comparison of the mean of the observations in spring and of the mean of these in Autumn gives 47″,21—,68p = 46,76 + ,84p. or p = 0″,30 from which also I infer that the parallax of α Polaris (if any) is too small to require to be noticed.

α Aquilæ.

Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.	Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.
		° ′ ″	+			° ′ ″	+
1809, July 20	E	45 0 32,48	0,48	1811, Aug. 6	W	45 0 28,89	,42
Aug. 21	E	27,44	0,32	10	W	30,46	,40
22	W	27,99	0,32	16	W	31,57	,36
23	E	29,60	0,31	19	E	28,83	,34
24	W	29,88	0,30	20	W	28,68	,34
27	W	28,35	0,28	22	E	31,99	,32
28	W	29,07	0,27	25	W	31,80	,30
1810, July 30	W	30,90	0,45	27	E	28,69	,28
Aug. 26	E	28,82	0,29	31	W	31,03	,25
1811, July 14	E	28,80	0,50	Sep. 1	E	29,55	,24
16	W	28,99	0,49	1812, Aug. 6	E	28,29	,42
20	W	29,18	0,48	7	W	29,29	,42
21	E	31,48	0,48	8	W	29,88	,41
22	W	30,77	0,48	9	E	32,15	,40
23	E	27,84	0,48	16	W	29,54	,36
26	W	30,63	0,47	24	E	28,13	,30
29	E	30,34	0,46	25	W	27,07	,29
31	W	30,81	0,46	26	E	28,79	,28
Aug. 3	E	31,38	0,44	Sep. 5	W	31,02	,21

The mean of the above 38 observations gives mean zen. dist. $= 45° 0' 29'',74 + ,38p$. The effect of annual parallax as to α Aquilæ makes the zenith distance greatest, Dec. 29, and least June 29.

α Aquilæ.

Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.	Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.
		° ′ ″	—			° ′ ″	—
1808, Nov. 29	W	45 0 32,49	0,44	1811, Dec. 13	W	45 0 31,40	0,50
Dec. 19	EW	34,22	0,51	18	E	32,63	0,52
22	EW	32,97	0,52	21	W	33,36	0,52
1809, Jan. 30	E	30,63	0,44	29	E	31,33	0,52
Feb. 11	E	32,42	0,37	1812, Jan. 4	W	32,56	0,51
16	E	30,73	0,33	8	E	29,84	0,50
1810, Feb. 4	E	29,17	0,41	21	W	29,68	0,48
13	W	31,58	0,35	29	E	32,10	0,44
18	E	31,58	,032	30	W	32,22	0,44
Mar. 10	W	33,26	0,16	1813, Jan. 20	E	31,08	0,48
13	E	31,06	0,13	25	W	33,61	0,46
1811, Jan. 27	E	30,53	0.45	Feb. 5	E	32,00	0,41
28	W	32,99	0,45	6	W	32,61	0,40
Feb. 3	W	32,92	0,42	9	E	31,75	0,38
13	E	31,80	0,35	15	W	32,01	0,34
19	W	34,16	0,31	19	E	29,78	0,31
23	E	32,29	0,28	20	W	31,98	0,30
24	W	33,55	0,27	21	E	31,07	0,29
Dec. 11	E	29,44	0,50	22	W	32,65	0,29

The mean of the above 38 observations gives the mean zen. dist, 45° 0′ 31″,87—,40*p*. Hence by comparing the preceding set of observations with these, we have $29'',74 + ,38p = 31'',87 - ,40p$ or $p = 2'',73$.

Hence the parallax of α Aquilæ = 5″,5. The refractions in the

French tables have been used in the above. Had Bradley's refractions been used, the parallax would have come out considerably greater. The value of p is less exact, on account of the smallness of its co-efficients.

A mean of 20 observations near six o'clock in the evening, gives mean zenith distance $= 45^\circ.0'.\ 30'',64 - ,1p$.
The mean of the above 76 $= 45.0.\ 30,80 - ,01p$.*

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* M. Delambre in his remarks on M. Piazzi's observations, proposes to examine the effects of the parallaxes in changing the right ascensions. This confirmation would be very satisfactory, and might be readily attained, were some stars so much affected by parallax as M. Piazzi has supposed. But if the parallaxes be so small as my observations tend to point out, no expectation of this kind could be entertained as to α Lyræ, Arcturus, and α Cygni.

As to α Aquilæ, the right ascensions in March and September would differ by about $\frac{4}{10}$ of a second of time, and, under the circumstances of the case, it would require attention to detect this quantity, but it might be done. If this difference exist it ought to be allowed for in computing the apparent from the mean right ascension.

Arcturus.

Time of observation	Face of Circle	Mean Zen. Dist. Jan. 1. 1811.	Mult. for Paral.	Time of observation	Face of Circle.	Mean Zen. Dist. Jan. 1, 1811	Mult. for Paral.
			—				—
1808, Oct. 27	E	33° 12′ 54″,86	,54	1811, Oct. 16	W	33° 12′ 55″,72	,47
31	W	52,88	,55	18	W	55,57	,48
Nov. 1	W	56,15	,56	25	E	55,02	,53
11	EW	53,55	,60	26	W	55,01	,53
27	EW	52,93	,61	Nov. 1	W	56,21	,56
29	EW	54,51	,61	3	E	52,72	,57
Dec 10	EW	53,14	,59	18	W	55,87	,61
13	EW	52,50	,59	19	E	55,71	,61
14	EW	52,74	,59	22	E	56,67	,61
1810, Sept. 6	W	52,56	,12	29	W	54,49	,61
10	W	57,61	,16	Dec. 1	W	53,94	,61
21	E	53,98	,27	1813, Oct. 14	E	56,02	,46
Nov. 5	E	53,75	,57	19	E	55,16	,49
6	W	55,48	,58	31	W	56,52	,56
16	W	56,62	,60	Nov. 2	E	54,27	,57
22	E	55,42	,61	3	W	57,61	,57
26	W	54,86	,61	11	E	55,23	,60
Dec. 1	E	55,97	,61	12	W	55,90	,60
10	E	53,57	,59	14	W	57,50	,60
1811, Oct. 11	W	56 74	,44	Dec. 14	E	56,32	,58
12	E	55,84	,45	16	W	57,69	,57

In deducing these results from the observations of Arcturus, the annual change of *N. P. D.* has been taken = +18″,81. The annual proper motion of Arcturus may be considered in some measure uncertain, and it may be thought that the conclusion respecting parallax will be affected thereby. But this is not the case. Let the annual variation in *N. P. D.* = 18″,81+e. *

Then the mean of the above 42 observations gives
the mean zenith distance = 33° 12′ 55″,11—,54p—,45e.

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* The annual variation in N. P. D. of Arcturus seems by my observations to be at least +19″,1. But the interval since they commenced is too short to speak with much confidence.

Arcturus.

Time of observation	Face of Circle	Mean Zen. Dist. Jan. 1, 1811.	Mult. for Paral.	Time of observation	Face of Circle	Mean. Zen. Dist. Jan. 1, 1811.	Mult. for Paral.
		° ′ ″	+			° ′ ″	+
1809 April 20	E	33 12 53,83	,52	1811 May 19	E	33 12 56,07	,61
28	EW	54,85	,56	26	E	52,35	,61
May 14	EW	53,70	,60	29	W	53,79	,61
21	W	54,64	,61	June 9	E	52,83	,60
June 25	EW	51,80	,52	12	W	53,89	,59
1810 April 25	E	53,27	,53	17	W	54,71	,56
26	W	56,24	,55	18	W	52,89	,56
27	E	51,90	,55	1813, May 11	E	53,32	,60
28	W	53,76	,56	16	W	56,07	,61
30	E	51,48	,57	20	E	54,16	,61
May 2	W	52,22	,57	28	W	54,95	,61
4	E	55,26	,57	29	E	52,87	,61
5	W	53,10	,58	30	W	55,48	,61
6	E	53,34	,58	June 2	E	55,52	,61
29	W	52,41	,61	4	W	52,69	,60
31	E	54,27	,61	5	E	53,81	,60
1811, May 11	W	56,77	,60	8	W	53,17	,59
16	E	53,11	,61				

From the above 35 observations the mean zenith distance $= 33^{\circ}\,12'\,53'',80 + ,59p - ,35e$.

Hence $55'',11 - ,54p - ,45e = 53,80 + ,59p - ,35e$

$p = 1'',1 - ,09e$.

e cannot be so great as half a second, and therefore $,09e$ is too small to be noticed. Therefore from these results the parallax of Arcturus $= 2'',2$.

And by 77 observations, the mean zenith distance $= 33^{\circ}.12'\,54'',45 + ,05p - ,4e$. By 15 observations in July and August, mean zen. dist. $= 33^{\circ}\,12'\,54'',\,50 + ,2p + ,68e$.

κ Cygni.

Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1. 1812.	Mult. for Paral.	Time of Observation	Face of Circle	Mean Zen. Dist. Jan. 1. 1812.	Mult. for Paral.
		′ ″	—			° ′ ″	—
1810, Mar. 9	W	8 46 26,21	,59	1813, Jan. 9	E	26,78	,88
10	E	26,31	,58	10	W	24,44	,88
17	W	23,91	,49				
18	W	24,77	,48	11	E	24,03	,88
1811, Jan 28	W	21,77	,89	19	E	24,50	,88
Feb. 3	W	23,59	,87	25	W	26,53	,90
23	E	26,42	,74	Feb. 4	E	25,81	,90
24	W	25,68	,73	5	W	26,46	,86
28	E	25,35	,70	6	E	22,83	,86
Mar. 12	W	26,22	,56	1813, Dec. 26	W	23,48	,81
14	E	25,64	,53	27	E	27,29	81
1813, Jan. 8	W	25,55	,88	28	W	24,40	,82
				1814, Jan. 4	W	23,81	,86

The above 24 observations give the mean zen. dist. = 8° 46′ 25″,07—,76*p*.

α Cygni.

Time of Observation	Face of Circle	Mean Zen· Dist. Jan. 1, 1812·	Mult. for Paral.	Time of Observation	Face of Circle	Mean Zen. Dist Jan. 1, 1812.	Mult. for Paral.
		° ′ ″	+			° ′ ″	+
1811, July 26	W	8 46 22,77	,90	1811, Sep. 5	E	8 46 26,63	,67
28	E	24,49	,90	1812, Aug. 24	E	24,03	,77
Aug. 3	E	24,24	,89	25	W	26,09	,76
10	W	23,08	,85	26	E	23,98	,75
13	E	24,31	,83	27	W	22,93	,74
16	W	22,16	,82	Sep. 5	W	24,81	,67
19	E	22,93	,80	7	E	23,87	,64
20	W	21,03	.80	10	W	22,52	.61
22	E	24,90	,79	11	E	23,67	,60
25	W	21,22	,76	12	W	23,46	,59
27	E	22,54	,74	Oct. 1	E	23,78	,33
31	W	21,59	,72				

The above 23 observations give the mean zen. dist. = $8^\circ\ 46'\ 23'',48 + ,74p$.

Hence $25'',07 - ,76p = 23'',48 + ,75p$

Therefore $p = 1'',06$

And the parallax of α Cygni = $2'',1$.

REMARKS.

If the results deduced from the preceding observations should be admitted, it follows that the brightest fixed stars are not so near to us as some others. α Aquilæ, which is far exceeded in splendor by α Lyræ and Arcturus is only at half the distance of the two latter. However extraordinary this may appear, it results from observations that appear to me fully adequate for the conclusion.

My observations on α Lyræ were commenced with the view of examining the question of parallax; but the results of the observations of α Aquilæ forced themselves as it were on my notice. This star would not on any account have been selected for the investigation. The effect of the annual parallax in declination is only about half the whole parallax: The star itself has not that splendid appearance that would lead us to suppose it as near as many others. Also its zenith distance in this latitude being so much as 45°, some uncertainty in so delicate an enquiry might be apprehended from refraction.

My conclusions may be considered as deriving little or no support from the results of the observations of M. Piazzi.

According to him (as appears from the Conn. des Temps 1808) the double parallax of α Lyræ is nearly five seconds, according to me only two seconds.

According to him the double parallax of Arcturus is less than that of α Lyræ (the quantity is not stated in Conn. des Temps.) according to me two seconds.

According to him α Aquilæ has no sensible parallax; according to me the double parallax is five seconds and an half.

According to him Procyon has a considerable double parallax amounting to about 20″; according to my observations it has no sensible parallax.

According to him Sirius has a considerable parallax. This star in this latitude is too much affected by refraction to afford any satisfactory conclusion.

The small changes of zenith distances which I find in α Lyræ, in Arcturus and in α Cygni, and from which I conclude the parallax of each, will, it is not doubted, make astronomers hesitate as to the degree of confidence with which they will receive them. It is not pretended that these quantities can be ascertained to the tenth of a second; but by continuing the observations, it appears to me, that I shall at last arrive at that degree of exactness. There seem to be no sources of errors in making these observations, which will not disappear by taking a mean of a great number of observations. However, until my conclusions are supported by other instruments, it is not likely that I shall impress astronomers with the same confidence which I myself possess as to the results.

The astronomer royal, Mr. Pond, observing with the new mural circle, made by Mr. Troughton, has not hitherto confirmed my results, although he finds indications of parallax in α Lyræ and α Aquilæ.* I had felt such confidence in my results that I did not doubt that one of the first services that would be rendered to astronomy, by the Greenwich mural circle, would be the confirmation of the existence of annual parallaxes in certain stars. But, allowing the greatest accuracy in the observer, and excellence in the instrument, I conceive a very probable account has been given, why this has not yet taken place. Many of the stars, even of the second magnitude, such as Polaris, γ Draconis, &c. may be affected by a parallax in declination, amounting to a fraction of a second. Were we certain that the standard stars were not affected by parallax, or had we ascertained the quantity, if any, then the method of observing by the mural circle would be far preferable to the methods of observing in which the plumb line is used.†

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* Phil. Trans. 1813, part 2.

† I can feelingly bear testimony to the great superiority of the mural circle over our instrument, as to the convenience of the observer, and the consequent facility of multiplying observations. In the mural circle no care is necessary but in making and reading off the observations. In our circle the previous examination of the plumb line is often a very tedious and sometimes unsatisfactory operation. Many observations have been lost thereby, a serious inconvenience in a climate ill adapted to astronomical observations. The calm weather which we so often experience during a high state of the barometer, both in summer and winter, is generally unfavourable to the astronomer, be-

The same number of observations that I have given might have been completed in a smaller space of time, but unfavourable skies, necessary interruptions, and the expectation of having my results confirmed by other instruments have made the earlier observations less numerous than they otherwise would have been. It soon appeared that increasing the number of observations would not materially change the results that I had already deduced. However the consistency of the observations in the several years may with some add weight to the conclusions.

My future exertions shall be directed in making such observations as may serve to throw further light on this subject,

If I should meet with any circumstances that shall appear to me to invalidate the conclusions I have now ventured to make, I shall cheerfully communicate them. I shall be fully satisfied with the consciousness of having, to the utmost, exerted myself, as my duty led me, in the examination of this important question.

ing attended with a cloudy atmosphere. Clear skies oftener prevail during high winds. These circumstances are much against the use of the plumb line.

MEAN NORTH POLAR DISTANCES OF FORTY-SEVEN PRINCIPAL FIXED STARS, JAN. 1, 1813.

Names of Stars.	No. of Obs.	By Ref. in French Tables. Co-lat. 36° 36′ 46″ 5 N. P. D. Jan. 1, 1813.	Ref. Brad. Tab. Co-lat. 45″,8 *N.P.D*	G	P	D
		° ′ ″	″	″	″	″
* Polaris	36	1 41 21,77	21,71	+ 0,08		+ 0,14
* β Ursæ min.	38	15 4 49,45	49,26	— 0,31		
* β Cephei	21	20 15 31,41	31,14	— 0,44		
* α Ursæ maj.	10	27 14 30,88	30,29	+ 1,17		
* α Cephei	9	28 12 13,90	13,30	— 0,83		
β Ursæ maj.	18	32 37 4,72	4,07			— 0,29
ε Ursæ maj.	19	33 1 22,05	21,44			
* α Cassiopeæ	8	34 29 22,59	21,91	+ 0,80		
ζ Ursæ maj.	8	34 54 42,68	41,01			
* γ Ursæ maj.	10	35 15 56,22	55,53	— 0,26		
* γ Draconis	27	38 29 3,70	3,00	+ 0,65		+ 0,28
* η Ursæ maj.	20	39 44 58,37	57,61	+ 0,27		
* α Persei	10	40 48 51,36	50,62	+ 2,05		
* Capella	30	44 12 20,71	19,90	+ 0,57	+ 2,34	+ 0,48
* α Cygni	22	45 22 58,34	57,52	— 0,60	— 0,42	— 1,90
* α Lyræ	51	51 23 0,84	59,93	+ 0,53	+ 2,21	+ 0,11
* Castor	10	57 42 47,54	46,64	+ 0,09	— 0,48	— 2,40
* Pollux	10	61 31 56,07	55,12	+ 1,23	+ 0,91	— 0,55
* β Tauri	18	61 33 44,22	43,19	+ 0,47	+ 0,37	— 2,28
* α Andromedæ	10	61 56 30,32	29,31	+ 0,30	+ 2,44	+ 0.81
* α Cor. bor.	19	62 38 55,51	54,44	+ 0,99	— 0,09	— 2,34
* α Arietis	9	67 25 36,76	35,82	+ 0,67	+ 0,41	+ 1,35
* Arcturus	20	69 50 19,33	18,19	+ 0,89	— 1,90	— 1,09
* Aldebaran	20	73 52 35,98	34,62	+ 0,74	— 0,79	— 1,64

Names of Stars.	No. of Obs.	Ref. by French Tables, Co-lat. 26° 36′ 46″,5 *N P D* Jan. 1, 1813.	Brad. Ref. Co lat. 45″,8 *N.P.D*	G	P	D
		° ′ ″	″	″	″	″
* β Leonis	18	74 22 56,44	55,22	+ 2,09	— 0,18	+ 3,83
* α Herculis	10	75 23 14,64	13,22	+ 0,82	— 3,17	— 2,26
* α Pegasi	15	75 47 52,80	51,71	+ 0,00	— 1,04	+ 0,19
* Pegasi	10	75 51 21,18	20,00	+ 1,00	+ 0,91	— 0,46
* Regulus	20	77 7 23,06	21,79	+ 0,90	— 0,57	+ 0,42
* α Ophiuchi	25	77 17 40,49	39,19	— 0,03	— 2,76	— 1,25
γ	10	79 50 1,34	0,11	+ 0,55	— 0,98	— 2,55
* α Aquilæ	30	81 36 59,85	58,54	+ 0,12	— 2,67	— 2,53
β	10	84 3 5,22	3,79	+ 0,30	— 0,53	— 3,31
* α Orionis	18	82 38 15,94	14,69	+ 1,03	+ 0,53	— 1,35
* α Serpentis	18	82 58 38,81	37,40	+ 1,86	+ 1,14	— 1,49
* Procyon	16	84 18 15,33	13,87	+ 0,49	— 0,41	+ 0,19
α Ceti	10	86 39 2,04	0,74	+ 0,01	— 0,46	— 0,67
α Aquarii	10	91 13 21,75	19,96	+ 1,68	+ 0,49	+ 0,90
α Hydræ	12	97 51 10,99	9,39	+ 1,91	+ 1,45	+ 0,82
Rigel	10	98 25 34,27	32,67	+ 1,18	— 0,61	— 0,41
Spica Virg.	13	100 10 51,33	49,23	+ 2,07	— 0,74	— 0,60
1 α Capricorn.	9	103 4 36,09	34,09	+ 1,36	— 2,16	— 3,04
2 α Capricorn.	10	103 6 52,03	49,68	+ 2,64	+ 0,57	+ 0,89
2 α Libræ	10	105 15 22,59	20,02	+ 2,67		+ 1,41
Sirius	10	106 28 4,27	2,47	— 1,77	— 2,23	— 2,11
Antares	10	116 0 16,77	13,77	+ 2,86	+ 2,04	+ 1,55

I find by above 500 observations of circumpolar stars the latitude of the observatory of Trinity College, Dublin, 53° 23′ 13″,5 using the French tables of refractions published in 1806. Or 53° 23′ 14″,2 using Bradley's refractions.

In the preceding catalogue the third column shews the mean north polar distance, Jan. 1, 1813, the refractions having been computed by the French tables, to which tables I give the preference for reasons assigned in the paper which follows this.

The fourth column shews the seconds of the north polar distances, as computed by Bradley's tables.

It appeared to me on several accounts of much importance, to compare observations made nearly at the same time by different instruments. The mural circle at the royal observatory, Greenwich, and the circle at the observatory of Trinity College, Dublin, may be ranked amongst the best instruments that have been constructed. As soon therefore as I was informed that the Greenwich circle was in use, I determined to repeat my observations of the principal fixed stars, and the present catalogue is the result of observations in the latter part of the year 1812 and in the year 1813.

To institute a comparison between the north polar distances deduced by Mr. Pond and myself, it is necessary that the same tables of refraction should be used by each. Therefore as Mr. Pond has used the tables of Bradley, I also computed my observations by the tables of Bradley, and the result of the comparison of the observations is found in the column *G*. The quantity in *G* is to be applied to the fourth column to give the north polar distances by the Greenwich mural circle.

The 30 stars marked * are those which Mr. Pond uses as standard stars; the north polar distances of which he has determined by a great number of observations in 1812 and 1813. (vid. Phil. Tran. 1813, part 2.) Now among these 30 stars there are 24 in which the results do not differ by 1″, four in which the differences exceed 1″, but do not amount to 2″, and two in which the differences exceed 2″, but do not amount to 2″¼. This is highly creditable to the divisions of our circle. In the Greenwich circle the errors of divisions, if any, will entirely disappear in a mean of a great number of observations, in consequence of the telescope being moveable. And in fact in this way Mr. Pond has ascertained that the errors of division of the Greenwich circle are too small to be noticed. (Phil. Tran. 1813, p. 281.) In our instrument the effect of the errors of division in the mean of the six readings of the microscopes, cannot be made to disappear. The above comparison shews satisfactorily that no material error can arise from thence.

For the stars not marked * the comparison has been made with the north polar distances given in the Phil. Tran. 1813, part 1. The differences as to these low stars are greater, and may probably be attributed partly to the uncertainty of refraction, and partly to the use of Bradley's tables. In Dr. Bradley's formula for refraction the effect of the change of temperature on the quantity of refraction is taken too great. This appears certain by the direct experiments of T. Mayer, Dalton and Gai-Lussac on the expansion of air at different temperatures. It also appeared evident to me by observations of low stars in different temperatures. The consequence of which is, that even supposing the utmost accuracy in the instruments and in the observations, the zenith distances of stars will appear greater in winter than in summer, and the more so the greater the zenith distance.

The column *P* shews the quantity to be applied to the fourth column to obtain the north polar distances according to M. Piazzi, at Palermo. His north polar distances given in the Conn des Temps, 1812, having been reduced to Jan. 1, 1813, and also reduced to what they would have been according to Bradley's refractions. I do not know the exact date of these observations, but I suppose them recent. I believe also that M. Piazzi takes the mean refraction at $45^{\circ} = 57'',4$ and makes the same allowance for changes in the thermometer as Dr. Bradley. If so, the correction to be applied to the north polar distances, as determined by M. Piazzi, to give what would have resulted from the use of Bradley's refractions $= -0'',69 - 0'',5\ (\text{tan. } N.P.D. - 53^{\circ}.\ 53')$. This quantity has been applied accordingly.

The column *D* is the difference between my results in 1809 and 1813. The quantities according to their signs are to be applied to the results in column 4, to give what would have resulted from the observations in 1809. In making this comparison, the annual motions in north polar distance, as given in the last catalogue of Dr. Maskelyne, have been used. These certainly are in several instances inaccurate from the proper motions used, and to this may be attributed some of the differences between 1809 and 1813, but it is by no means a sufficient explanation as to others. In the case of β Leonis, particularly, there appears a difference that I cannot attempt to account for. Considerable differences between the results of observations of the same star when separated by several years have, however, been before observed in several instances, and yet remain to be accounted for. A comparison of the means of the results of the observations of Dr. Hamilton, at Armagh, M. Piazzi, at Palermo, and Mr. Pond, at Westbury made about the same period, (Phil. Trans. 1806) and of the present results of the Greenwich, and of our instrument, furnishes a striking instance. A comparison some years hence of the present results and of new ones obtained by the same instruments will probably clear up this point.

It may also be remarked that the observations in 1809 were computed by Bradley's refractions, and also no attention was paid to the circumstance of parallax. The results of 1813 are from observations made when the zenith distances from the effects of parallax were greatest and least. Hence also perhaps may be explained part of the differences in column *D*.

In computing my observations I have used max. aberration of light = $20'',00$

Lunar nut. in *N.P.D.* $= 8'',28$ sin. (*AR*—Long. moon's node)
$+ 1,22$ sin. (*AR* + Long. moon's node)

Solar nut. in *N.P.D.* $= 0'',48$ sin. (2 Long. sun—*AR*.)